8. Quality of Life

Human Health

study conducted by

Mark L. Wilson and Peter J. Sousounis
University of Michigan, Ann Arbor, Michigan

Current Stresses

Heat-related Morbidity or Mortality

A variety of weather phenomena can cause injury and death to humans. People who lack protection to extremely hot or cold weather will eventually suffer from disturbances of normal physiological functions. Exposure to extreme, prolonged heat is associated with cramps, fainting (syncope), heat exhaustion, and ultimately heat stroke. Within limits, however, what is meant by "extreme" is somewhat relative, partly depending on previous exposure, physiological adaptation, age, and other health conditions. Furthermore, the impact of temperature extremes depends on the length of time that people have been exposed to local conditions, socioeconomic status and ability to cope, genetic predispositions to various conditions, and various physiological factors [8-1]. Some "heat waves" may last for a few days or for weeks, but the difference can influence how people with previous exposure or social conditions respond. Long or repeated heat waves may not allow people's bodies to recover from the heat. Also, since heat waves often occur with little or no rain, high humidity, elevated ozone, and other air pollutants (NO_2, SO_2, and particulates), susceptibility to these conditions also will affect health outcomes.

Climate change impacts on human health in the Great Lakes region are likely to be greatest in urban areas, especially where extremely high temperatures historically have been rare. For example, July 1999 was the hottest on record in New York. As many as 70 people died in Chicago during a 1999 summer heat wave with temperatures reaching 99°F [8-2]. But, heat waves are not new to Chicago. In 1995, more than 700 (most of them elderly) died from exposure to extreme heat. The impact from heat stress can be minimized through appropriate behavioral adaptations, e.g., using air conditioning, wearing light clothing, and maintaining hydration. Perhaps more important than the daytime high temperatures are the high nighttime lows, particularly in urban areas. Because the poor, elderly, very young, and otherwise ill tend to be less able to withstand extreme temperatures, they are more susceptible to the effects of these extremes. In addition, persons who must work outside or who lack access to indoor cooling also are at greater risk.

Output from the HadCM2 and CGCM1 models was examined to see how high temperatures would increase from the present (e.g., 1975-1994) to the end of the 21st century (e.g., 2080-2100). Model-forecasted atmospheric thicknesses were used rather than model-forecasted high temperatures, based on the assumption that this deep tropospheric parameter is a more accurately-forecasted variable than surface temperatures and so is a better proxy for identifying extreme heat episodes in GCMs. The results from both models for the warm season (May 1 – October 31) are shown in Figure 8.1. The CGCM1 model suggests a significant increase in days above 90°F – while the HadCM2 model suggests a more modest increase. Additionally, the distribution of temperatures in the HadCM2 model is broader than that in the CGCM1. Interestingly, both models suggest a decrease in interannual variability – in contrast to the popular notion that weather may become more variable.

Severe Weather Events

In addition to extreme temperatures, other impacts from short-term, extreme weather events such as floods, tornadoes, and blizzards, may affect health. In the Great Lakes region, heavy precipitation events have increased in frequency over the last 100 years. Both the HadCM2 and CGCM1 suggest these will continue to occur with increasing frequency. Unlike the prolonged periods of extreme heat that gradually cause death, extensive precipitation producing floods can cause immediate injury and death. Future changes in other extreme weather events are difficult to assess. The historical record indicates a slight decrease in thunderstorms for the Central US and a significant increase for the entire US in tornadoes over the last 50 years [8-3]. Because a tornado has to be seen before it can be counted, these numbers may be skewed by increasing population density. Additionally, GCM limitations (e.g., in resolution), preclude an ability to assess whether frequencies or intensities of these types of (small scale) extreme weather events, such as severe thunderstorms or tornadoes, will change. Even if such events decrease (slightly) in frequency, they will likely continue to cause more property damage because of increases in population, wealth, and inflation that will likely continue. Indirect effects from wind, flooding or drought may also produce longer lasting and further reaching impacts on housing, food production, drinking water, and social infrastructure. The extent to which such events will harm people's well-being largely depends on early warning and disaster preparedness.

Air Pollution and Respiratory Diseases

Another possible impact of climate change and variability on health in the region involves the air that we breathe. Many forecasts suggest increases in ground level air pollutants, some of which may exacerbate asthma and other respiratory illnesses and tax cardiac function [8-4].

Local levels of gases such as sulfur dioxide, nitrous oxides and ozone, as well as various kinds of aerosolized particulate matter already have been increasing in some areas. In addition, warmer weather can enhance fungal spores and pollen, which in turn may increase allergic reactions. As with most possible health impacts, the association with climate is not well understood, making forecasts of future risk is uncertain. In the Great Lakes region, air pollution associated respiratory disease has not been well studied. Results suggest that air pollutants are but some of many factors involved in the etiology of respiratory diseases. Furthermore, different studies have produced inconsistent results.

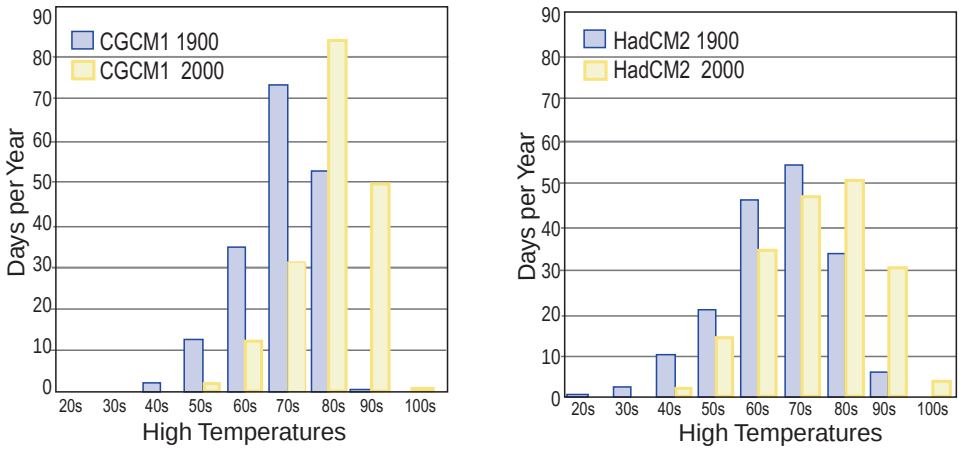

Figure 8.1: Annual GCM-derived distributions of days with high temperatures per year for the warm season (May – October) for a current 20 year period (labeled 1900) and for a future 20 year period (labeled 2000). For the CGCM1 model (left) the current period is 1975-1994 and the future period is 2080-2099. For the HadCM2 model (right) the current period is 1970-1989 and the future period is 2078-2097.

A simple analysis of the output from the CGCM1 and HadCM2 models suggests that the number of days with synoptic patterns that are conducive to high ozone will increase by the end of this century. High ozone days are basically characterized synoptically by southwesterly flow, high pressure (e.g., anticyclonic flow), and high heat (e.g., temperatures above 90°F). Table 8.1 shows how the number of days when all three conditions exist simultaneously will increase for Detroit, Michigan – primarily as a result of more days with high heat.

Infectious Diseases and Weather Variation

Many impacts of climate change on infectious diseases have been suggested. New studies are currently underway to examine whether temporal variation in incidence of selected infectious diseases is related to that of temperature, precipitation, and other weather variables [8-5]. In collaboration with the Michigan Department of Community Health, case data from 1984 through 1998 are being studied using time-series analysis. County-specific data for reported cases of aseptic meningitis, hepatitis A, and salmonellosis have been transferred and organized for initial study. Possible links to climate are suggested for all three diseases since the temporal pattern of each is strongly seasonal and there is considerable variability from one year to the next. However, before more extensive time-series and autocorrelation analysis can be undertaken, the data must be adjusted in various ways. First, local, point source outbreaks must be considered and possibly eliminated. Second, GIS-based mapping by county shows that there is considerable variability among regions, suggesting that analysis by subregions may be needed. In that case, weather data from stations within each region will be used in conjunction with synthetic monthly average data to search for temporal patterns. Finally, it may be necessary to calculate age-specific incidence rates since each disease has more cases in certain age groups and the proportion of the population in each age group may differ among regions and over time. Once these adjustments have been made, it will be necessary to search for patterns of association over time that might demonstrate occurrence of excessive cases following unusual weather patterns. In addition to these diseases, similar analyses of cases are planned for cryptosporidiosis, giardiasis, histoplasmosis, influenza, and leptospirosis, among others.

Coping Strategies

Responses to various health threats posed by climate change will vary considerably depending on the etiology of each condition [8-6]. Extreme heat-associated morbidity and mortality is well understood and technically easy to prevent. If increased extreme heat events were to occur in the future, then a combi-

Model	Years	Southwest flow	High pressure	High heat	High ozone
Current 20-year period					
CGCM1	1975-1994	1570	2205	10	3
HadCM2	1970-1989	1295	2162	140	22
Future 20-year period					
CGCM1	2080-2099	1603	2171	987	377
HadCM2	2078-2097	1254	2167	582	157

Table 8.1: Total number days with favorable synoptic conditions for high ozone during the warm season (May – October), in Detroit, Michigan . For the CGCM1 model the current period is 1975-1994 and the future period is 2080-2099. For the HadCM2 model the current period is 1970-1989 and the future period is 2078-2097.

nation of improved forecasting, information distribution, and special assistance to high risk populations should compensate for most of the increased risk. Physiological adaptation is possible over a period of years, but since most stress occurs during short-term extreme events, this may not allow for such adaptation. Improved economic well being and education of urban poor and elderly would allow these groups to better cope through increased use of fluids and air conditioning.

Other extreme events such as tornadoes or floods demand better forecasting and advance warning, but responses depend more on preparedness and disaster relief than individual behaviors. Preventing construction of dwellings on flood plains, improving the construction of houses, and enhancing knowledge of responses to extreme winds or floods should help to reduce impacts from these events. Unusual precipitation that may not produce catastrophic flooding yet may impact on infectious diseases can be addressed with a combination of improved storm drainage systems, and warnings to avoid high-risk areas. The impacts of air pollutants on health can be decreased if susceptible people are given warning of severe conditions. The eldery or those with preexisting respiratory conditions may be warned to minimize time spent outdoors during the stagnant air conditions assoiciated with increased ground level air pollutants. In extreme cases, the only response may be to move from more polluted urban areas, or even to leave the Great Lakes region entirely for less polluted and less humid climates.

The climate link to variability in infectious disease risk is different for each disease, but appears to be important for certain diseases. Most are highly seasonal, suggesting that normal variation can be foreseen and appropriate warning made. A few such diseases (e.g. influenza, rabies, Lyme disease) have effective vaccines, which can be obtained prior to exposure. Others have known behaviors associated with risk, making education and behavior changes the most effective response. For example, risk of most vector-borne diseases of the region (e.g. Lyme disease, Eastern Equine Encephalitis, etc.) can be reduced significantly by changes in activity, clothing, or housing, so that responses mostly involve education. Finally, many of these diseases respond to post-exposure antibiotics, permitting treatment that is usually curative.

Information & Research Needs

The difficulties, inadequacies, and uncertainties in both the forecasts of possible climate change and the effects on public health demonstrate that major research efforts are needed to better understand and develop eventual mitigation strategies [8-7]. Diverse biological and physical systems, the long time during which processes are likely to occur, and the uncertainty inherent in these interactions all suggest that research has become vitally important, yet extremely difficult. More research is needed, but so is a shift in the kinds of investigations. At present, systematic, long-term surveillance data on many diseases is inadequate to permit rigorous study of historical patterns. Many of the important interactions involve diverse variables that range from physiology to economic policy, from microbiology to social behavior. New theory and analytic tools are needed that not only incorporate such interactions, but also analyze climate variability as part of a much larger arena of environmental change, that considers human disease as part of political ecology.

Long-Term Monitoring and Analyses

As many recent reports have argued, the problem of emerging diseases, disease surveillance in the US, and surveillance assistance to other countries are woefully inadequate. Without systematically gathered epidemiological records, the basic information needed to track and retrospectively analyze changes in disease patterns is lacking. Disease gathering in the Great Lakes region differs among cities and states, making some surveillance data difficult to interpret. These data are critical to studies aimed at understanding disease trends, analyzing retrospectively changes associated with the environment, and eventually modeling future outbreaks and situations of high risk. Such data is vital for developing casual hypotheses and is the

best way to test these predictions prospectively. In addition to the important role that surveillance plays in recognizing new and emerging diseases, surveillance data is essential to the study of climate impacts on health.

Environmentally-Based Research and Evaluation

Another new research emphasis could focus on identifying and understanding disease-specific environmental factors that can be used to prevent outbreaks before they occur. Climate variables are among many such environmental factors. In the Great Lakes region, well-designed experiments are needed to explore how multiple variables interact, and how diverse climate conditions impact on their interactions. Classical laboratory experiments aimed at demonstrating dose-response or transmission of infectious agents cannot fully replicate the diverse conditions that occur under natural climate variation. Unfortunately, an increasing focus on simple experiments that produce rapid results has meant that long-term prospective observations have declined. Other experiments that evaluate how changing environments may lead to rapid evolution will enhance understanding of when adaptation may occur in the face of gradual climate change during the next century.

Multidisciplinary Perspectives and New Analytic Techniques

Not only must the extent and coverage of observations be improved, but new methods for gathering or analyzing data and interpreting patterns are also needed. The complex interactions among physical, biological, and socioeconomic variables that determine disease risk suggests that more multidisciplinary studies are needed. In addition to the traditional disciplines such as climatology, immunology, or physiology, the determinants of health outcome involve sociology, psychology, and economics, etc. Thus, new methods are needed that could include theoretical studies of complex dynamic behavior, spatial statistical investigations of disease ecology during environmental change, or integrative modeling of socioeconomic development impacts on pathogen transmission. Studies of multivariable interactions that may have spatio-temporal fluctuations, nonlinearities, thresholds, or time-lags will require different conceptual foundations and new analytic tools. Methods for studying interactions among qualitatively different kinds of variables are needed to address the complex processes that occur as climate change impacts on health. More simulation modeling involving socioeconomic and behavioral adaptation will be particularly instructive.

Rural Landscape

study conducted by

George M. Albercook and John D. Lindeberg
Center for Environmental Policy, Economics and Science (CEPES), Ann Arbor, Michigan

Significant changes have occurred in the rural areas of the Great Lakes region during the last few decades. Two trends in landuse can be identified that have relevance to this change. The amount of land under cultivation decreased from 1987-1997 by 5%. At roughly the same time (between 1980-1993) forest cover increased 3% (Chapter 6). In combination, the pressures of rural development and the urbanization of formerly rural lands (in many cases prime agricultural land) are dramatically changing the face of the region's landscape.

Current Stresses

The two main stresses are sprawl and climate change. The most significant current stress to the rural landscape is the urbanization and general sprawl of population beyond the traditional boundaries of the large metropolitan areas. For instance, while the traditional metropolitan areas of Milwaukee and Detroit have either lost population or held steady, the surrounding rural areas have dramatically increased in the classification of urban land that was formerly rural.

The negative aspects of this trend are considerable. They affect energy consumption by increasing commuting and home heating requirements. They affect runoff by decreasing vegetation, increasing pavement and other hard surfaces, and introduce new pollutants (lawn fertilizers, automobile emissions etc.) into the nearby watercourses and airsheds. They threaten local wetlands with increased runoff and pressure from contractors and developers seeking to increase buildable lots. They require additional infrastructure in the form of roads, water, sewer, and energy delivery systems that require construction and disruption of local landforms and ecosystems.

Not all of the rural development is simply from families escaping the traditional urban neighborhoods. It also represents the trend of "rural sprawl" which marks the trend of aging baby boomers, desire to retire and vacation near bodies of water. While vacationers once traveled to relatively primitive cottages near lakes and rivers "up north" in the Great Lakes region, now vacation residences of 2000 square feet complete with the "urban yard ethic" are commonplace beyond the traditional suburban areas near major metropolitan centers [8-8].

Good examples of this type of threat include the Lake Superior shoreline in northern Wisconsin and the Lake Michigan shoreline around Grand Traverse Bay and the Leelenau Peninsula in northern lower Michigan. Where "... all the best sites already sprouting seasonal and permanent homes, developers went to work on 'marginal' lands – sites with steep slopes, adjacent to large bogs or wetlands, shallow weedy bays, poor access, or terrain that block a view or access to the water [8-8]." People are willing to travel farther and farther for a larger home on a smaller lot.

Grand Traverse County is another region experiencing the effects of rural sprawl. Here in the Cherry Capital of the World the year-round population of 90,000 swells to 2 million in the summer with the influx of seasonal visitors and tourists [8-9]. It is also a prime place for retirees. A recent national survey placed the region as number 8 in a list of the nation's Top Ten places for retirement. Human waste disposal alone has become a prob-

lem of epidemic proportion. Local septic systems designed for less intense and less frequent use have become almost universally overloaded. Consequently, the flows of nutrients and pathogenic bacteria have increased – both into the local ground and surface water. Temporary strategies for managing this additional waste have been further jeopardized by insufficient capacity for the treatment of septage (pumped material from septic tanks) at the few local sewage treatment plants. So traditional strategies of "pump and treat" for the septic needs of lake homes can no longer be predictably undertaken [8-10]. The sudden need to expand sewerage service to many new residents and visitors has taxed municipal budgets. The problem will probably continue for the foreseeable future.

Of course, all of these pressures lead directly to the degradation of the attractive features of the rural landscape that attracted the population shift in the first place. The challenges of managing growth in areas facing both urban and rural sprawl are significant and currently occupy a great deal of planning and political effort.

Climate Change and Related Stresses

The current stresses on the rural landscape are already significant. Climate change in the form of increased temperatures and anomalous severe weather events will serve to further challenge a landscape that is already in the process of profound change.

Some examples of exacerbated change that might be expected include the following:

- Higher water temperatures in combination with development-related storm water management issues (e.g. increased runoff, greater concentrations of pollutants, decreased buffering capacity from wetlands) will increasingly stress fish stocks and decrease the attractiveness of lakeside or riverside home ownership for some.

- Climate-related lowering of lake levels will have a dramatic effect on shoreline [8-11]. In some cases, this will result in reclamation of beach areas (primarily around the Great Lakes) but in other cases it will make real estate along lower inland lakes and rivers less attractive.

- Challenge to arboreal forests from both the warming of the climate and development will lead to further forest loss and species weakening.

- Rural parcelization will reduce of migration pathways for both plant and animal species that become challenged by warming and development could have a dramatic effect on the ecosystem's ability to relocate and recover from warming.

A third stress comes from the non-indigenous species that have entered the Great Lakes region for hundreds of years. The harmful species quickly take hold often without any natural predators. The results can be costly to the economy and the environment. Probably the most destructive invader in the region's waterways is the sea lamprey. Millions are spent annually to reduce their populations, for left uncontrolled, sea lampreys can decimate fish harvests – from 17 million pounds to virtually zero [8-11]. On land, the gypsy moth caterpillar is well known in many forests. In Michigan, large forest tracts have been defoliated [8-12]. Many trees in the region are favored by the caterpillar including oak, aspen, birch, basswood, tamarack and apple. Usually, if the forest is healthy, the trees can survive a gypsy moth attack. Unhealthy trees will die because of the fungal disease and insects that descend on the forests following a gypsy moth attack.

It seems that the greatest effect on the rural landscape is the current trend of sprawl – whether it is urban or rural. While climate change will no doubt worsen the effects of this trend, it also seems clear that the primary driver is sprawl.

Coping Strategies

During a review of the current stresses and impacts of future climate change, a number of critical areas were identified that might need extra special coping strategies. Some of these strategies include:

1) Public programs for purchase of greenspace and wildlife corridors

2) Investment in rural sewerage services, particularly around developed rivers and lakes

3) Consistent zoning approaches to encourage minimum impact development, and

4) Stronger enforcement of existing wetland and stormwater runoff requirements

Recreation and Tourism

study conducted by

John D. Lindeberg
Center for Environmental Policy, Economics and Science (CEPES), Ann Arbor, Michigan

Recreation and tourism in the Great Lakes region incorporates a variety of activities ranging from outlet mall shopping to ice fishing. Some of the activities that were reviewed with particular attention for this study include: fishing (both inland and lake); snowmobiling; skiing; pleasure boating; leaf peeping; bird watching; hiking; sightseeing (driving); hunting; gambling; and shopping. The region's significant natural beauty and cultural features combine to attract tourists from all over the Midwest.

Current Stresses

Tourism is an important portion of the region's economy. However, it also has significant stresses with which it is already coping. Some of these stresses are specific to the industry and others are specific to the region.

Industry Specific Stresses

Perhaps the greatest current stress to the tourism industry is its own inherent instability. Tourism is primarily a service industry that is seasonal and highly dependent on low wage and benefit-free positions to staff its busy times at both eating and lodging establishments. Economic prosperity or woe during any given season is frequently dependent on normal weather fluctuations and other variables like gas prices and general consumer confidence. For instance, skiing and ski resort operation in the Great Lakes is more economically threatened by small snowfall fluctuations than its competitors in the Far West. So, relatively minor changes in snowfall can significantly reduce skiing days and total industry revenue generation.

Region Specific Stresses

Regionally specific current stresses to the economy include ongoing water quality concerns about the Great Lakes (primarily Lakes Michigan and Erie) and continuing difficulties with the influx of invasive species. Both of these factors negatively affect the attractiveness of the biggest resource in the region – the Great Lakes. There are clear linkages between water quality and the appeal of water recreation. Areas that are perceived to be contaminated because of lowered water quality may reduce the attractiveness of fishing and pleasure boating. Additionally, tourism in the region continues to grow significantly across the board. This in turn is leading to resource overuse and will ultimately lessen growth of this sector unless additional resources (hotel rooms, campsites etc.) can be developed in response to demand.

With the exception of tourism drops in Minnesota during 1992-93 due to flooding and an exceptionally cold summer, the region has seen healthy growth in tourism during the 1990s. Even issues of concern like Great Lakes water quality have shown improvement from their difficulties twenty years ago [8-13].

Climate Change Related Stresses

Climate change in the form of rapidly rising temperatures over the next century will likely have significant effects on tourism in the upper Great Lakes region. Consider the following effects:

- Lengthened Tourist Season – Higher average temperatures translate into longer tourist seasons in the fall and spring. It is likely this will result in a longer season, especially in the fall, with increased economic activity.

- Warmer Lakes/Rivers: Reduced Fish Stocks – Both diversity of fish and total amount of fish is likely to decline as lakes and streams warm between 4-14°F [8-11].

- Great Lakes Whitefish – Less ice cover could cause rapid decline in whitefish population because of increasingly unprotected spawning areas

- Leaf Color Viewing Reduction – Higher temperatures (which may challenge species by pushing them beyond their preferred climate envelope) suggest a reduction of the quality of the leaf-related color tourism in the region through premature leaf fall off and overall species die-off [8-15].

- Winter Sport Reduction – Reduced ice coverage and snow depth will harm the ice fishing, snowmobiling and skiing industry [8-16].

- Increase in Exotic Species – Because colder winter temperatures have kept some of the exotic species at bay, increased temperature could greatly increase invasion of exotics [8-14].

It seems likely that a superposition of the impacts of climate change on top of current stresses will ultimately result in the greatest impacts. Therefore systemic responses will be the most important to understand and project. For instance, the combination of climatically challenged ecosystems within the most popular tourist destinations in conjunction with increased tourist pressure could result in sudden and dramatic degradation of the sensitive ecosystems. In the long run, significant degradation of the region's tourist attractions could have economic consequences.

Similarly, increased development pressure in rural areas, particularly in areas around inland lakes and rivers, has led to more concentrated and more polluted storm water run-off. The added effect of dramatic warming of these water bodies will then more quickly drive the cold and cool-water species out of existence. Alleged replacement of these fish stocks with other angler-friendly species (e.g. walleye, pike) remains for the most part unsubstantiated.

Coping Strategies

During a review of the current stresses and impacts of future climate change a number of critical areas were identified that might need extra special coping strategies. Some of these strategies include:

1) Examine ecosystems carefully for stress impacts to look for indicators that growth and warming will have compounding negative consequences;

2) Manage tourism growth in areas that will benefit from climate change and in areas that will be hurt. For example, make sure that facilities are sufficient to take advantage of longer warmer summers while helping communities that are hurt by loses is winter sports;

3) Create policy initiatives that offset economic dislocation in areas and populations especially hard hit by the negative effects of lost tourism through climate change.